Proposal

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Non–Linear Analysis of Soil–Pile–Structure Interaction on Structures with Piled Raft Foundation

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1. Background

Deep foundations are conventionally designed by implementing large safety coefficients for piles. The piles in a pile foundation are positioned in a way they bear the whole load exerted by the structure. Although the pile foundation cap, which is usually in form of raft foundation, is in close contact with the soil, the loading share of the cap is usually neglected in comparison with the total loading capacity. In recent decades, increasing the knowledge about these foundations, using pile foundation and connecting it to the raft foundation, so that it would fully contact the soil, have significantly resulted in cost effectiveness of the project and increased efficiency of the foundation [1]. In this type of foundations, the raft also participates in structural load-bearing. This type of foundations are called "Piled Raft Foundation".

Composite piled raft foundations are composite structures consisting of pile, raft, and underlying soil. Given this scheme, piles are generally responsible for controlling the subsidence, rather than bearing the whole load. This type of foundations have positive effects such as reduced uplifting caused to excavation, reduced subsidence, relative subsidence, and slipping and, in case of high load eccentricity, they make actions and reactions concentrated and reduce the bending moment of the raft component. Application of piled raft foundation is appropriate when the raft foundation has sufficient loading capacity, but the subsidence or relative subsidence exceeds allowable values. In contrast, in some cases, for example when the soil profile near the surface consists of soft clay, or soft compressive layers are in relatively shallow depths, etc., using piled raft foundation might be undesirable [2]. However, using piled raft foundations has some disadvantages in terms of analysis and design as the soil-structure interaction must be considered in it, which is very complicated. For tall buildings, due to the relatively large load exerted on the foundation, varied length piled raft system is used. In order to control differential subsidence in this method, the tallest piles are usually placed in the middle, while short piles are placed on the edges.

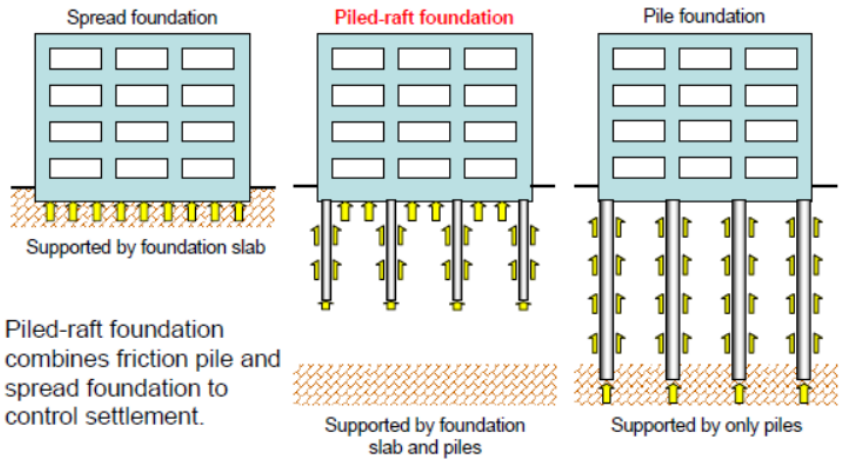

Figure 1. A comparison between the performance of raft foundation, pile foundation, and piled spread foundation

2. Aims

The purpose of this study is to investigate soil-pile-structure interaction in changing dynamic properties of the structure, as well as the performance of pile foundation in a piled raft foundation system. The changes in the amount of energy dissipation of the structures and foundation loading capacity, taking into account the interactions, are studied.

3. Research Methodology

The behavior of a composite piled raft foundation is so complex that it cannot be dealt with by analytical methods. But finite element method is very comprehensive and adaptive to study complex problems. In order to investigate soil-pile-structure interaction, a number of tall structures with different number of floors and different lateral loading systems were modeled in PLAXIS 2D finite element software. One of the important and effective parameters in this analysis is the type of soil in the model considered. In this regard, it has been tried to select three soil samples with various and common properties. Researches of Wulandari at al. (2015) [3] are used in this section.

Another important parameter in the modeling is the depth and number of piles modeled. In this regard, efforts have been made to examine the effect of these two parameters on interaction behavior of the system by changing them within reasonable ranges.

4. Significance

Deep soft soil deposits usually appear during construction in coastal areas. In order to mobilize the topsoil to sufficiently participate in the piled raft foundation interaction, the piled raft foundation scheme has been extended to a new type of foundation called composite piled raft foundation. This type of foundation is an economic approach for foundation designers in

coastal areas. In composite piled raft foundation systems, short piles made of elastic materials, such as soil-cement columns or sand-gravel columns, are used to improve loading capacity of the lower surface natural soil, while long piles made of relatively rigid materials, such as reinforced concrete, are embedded in deep layer of hard clay or other load-bearing layers to reduce subsidence. Sand-gravel pads are also implemented between the raft component and piles aiming to re-distribute and adjust piles tension with the subsoil [4].

The load capacity of piled raft foundations depends on the interactions prevailing in them. The details of the effects of interactions between piled raft foundation elements are shown in Figure 2, which include [5]:

- Pile-Soil-Interaction
- Pile-Pile-Interaction
- Soil-Raft-Interaction
- Pile-Raft-Interaction

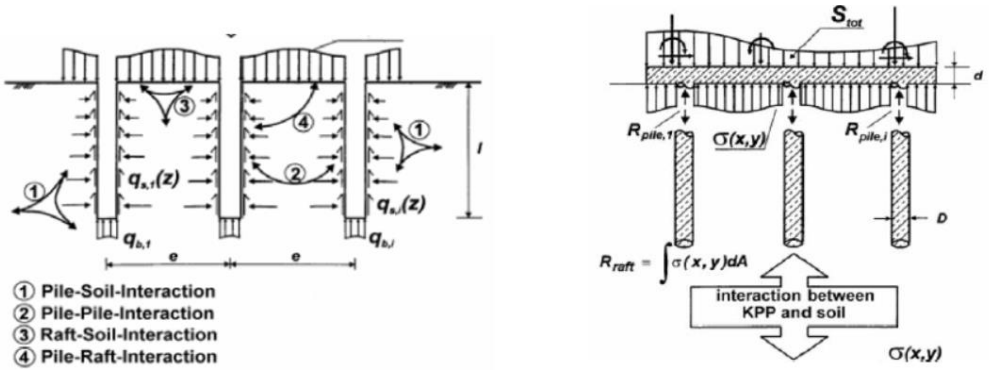

Figure 2. Different interactions prevailing in a composite piled raft foundation

5. References

6. [1] Shukla, S. J., A. K. Desai, and C. H. Solanki. "A behavioural study of dynamic soil structure interaction for piled raft foundation with variable sub soils by time history fem model." *International journal of GEOMATE: geotechnique, construction materials and environment* 8.1 (2015): 1288-1292.
7. [2] Poulos, H.G., (2001), "Pile Raft Foundations: Design and Applications," Geotechnique, 51 (2), pp 95–113.
8. [3] Wulandari, Paravita Sri, and Daniel Tjandra. "Analysis of piled raft foundation on soft soil using PLAXIS 2D." *Procedia Engineering* 125 (2015): 363-367.
9. [4] Shahu, J.T., Madhav, M.R., Hayashi, S., (2001), "Analysis of soft ground granular pile – granular mat system," Computers and Geotechnics, 27 (1), pp 45–62.
10. [5] Poulos, H.G., Small, J.C., Ta, L.D., Sinha, J., Chen, L., Comparison of some methods for analysis of piled rafts, Proceedings to 14th International Conference on Soil Mechanics and Foundation Engineering, Hamburg, Balkema, Rotterdam, Vol. 2, pp. 1119-1124, 1997.